DEMONSTRATION OF INNOVATIVE ELECTRICITY MARKETING OPTIONS FROM DECENTRALISED GENERATION – THE BADENOVA SHOWCASE

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ABSTRACT

As energy supply systems change from former centralised structures to decentralised, distributed ones, new challenges rise. Decentralised electricity generation had its initial incentives from federal supply mechanisms such as feed-in tariffs. Now it needs to adjust its operation management to demands of various energy market actors, e.g. consumers or grid operators. Therefore alternative marketing options for electricity from a combined heat and power (CHP) installation in Southern Germany are assessed in this paper. Direct trading into the EEX electricity spot market is considered as well as offering positive and negative tertiary control at the power reserve market. Optimisation of net heat production costs (NHPC) has shown that in case of trading both into the EEX spot and the power reserve market NHPC even turn negative, depending on the season. Sensitivity analysis of the results has shown that the price of natural gas has prior influence on the results, but natural gas price changes may be compensated partially by electricity price changes.

INTRODUCTION

Recently, energy supply systems are underlying structural changes, due to increasing shares of small scale renewable and efficient electricity generation. This development is driven by various factors, such as supporting regulative framework conditions in form of subsidies (e.g. feed-in tariffs). The liberalisation of European electricity markets gives the chance for smaller investors and market players to engage in power production. Nevertheless, prevailing remuneration systems as the German CHP (combined heat and power) Act cannot be seen as long-term instruments for fully integrating renewable and efficient electricity generation into our energy systems. Purpose of this work is to show options for direct marketing of electricity by offering standardised electricity products at the power market. This is demonstrated exemplarily with the "Friesenheim" CHP installation owned by the public utility badenova*WÄRMEPLUS* located in Southern Germany.

METHOD

First, the cogeneration plants connected to a district heating system, with additional system components such as auxiliary boilers and thermal storages, are described by their techno-economic parameters and their current mode of operation. This leads over into description and analysis of alternative operation management strategies. The approach of this paper is based on the work of Streckiene [Streckiene et al., 2009] and goes into further analysis of economics regarding power reserve market trading. Optimisation of the system operation management is based on the modelling software package energyPRO, developed for combined techno-economic analysis and optimisation of cogeneration. Economic feasibility of direct electricity marketing (combined offering at the spot market and offering tertiary control) is analysed with focus on selected periods of time. This approach is based on recommendations for alternative electricity marketing options for decentralised generation from [Obersteiner et al., 2008]. Finally, sensitivity of net heat production costs is assessed by the variation of parameters such as size of the thermal storage, electricity spot prices and primary energy prices.

DESCRIPTION OF THE “FRIESENHEIM” INSTALLATION

The “Friesenheim” CHP installation, located in Southern Germany, was built in 1989 by a small local utility. The main intention of the installation in the past was to reduce electricity peak loads in the distribution grid. Due to liberalisation of the energy markets that started in 1998 peak load reduction was not in the focus anymore. Today the installation is heat demand driven, supplying a small local district heating system (80 heat consumers, 2.5 km of pipelines). Electricity generated is fed into the grid and remunerated after the German CHP Act. Since 2007 both plants are owned by the local utility Badenova WÄRME*PLUS*.

In the following a short overview over techno-economical parameters of the installation is given in a table:

Components	**Electric power [kWel]**	**Thermal power [kWth]**	
Total power installed	**2300**	**4700**	
2 peak load boilers		650	
5 CHP units	460	680	
Other components			
2 thermal stores with 45,000 l each, storage temperature 90°C, 3.5 MWh of storage capacity			
Fuel type: natural gas			
District heating grid with 2.5 km of pipelines, flow temperature 90°C, return temperature 55°C			
Economical parameters			
Natural gas price	47 €/MWh		
Average EEX electricity price	65.73 €/MWh		
CHP bonus	0 €/MWh		
Avoided grid utilisation	15 €/MWh		

Table 1: Techno-economical parameters of the “Friesenheim” installation

The operation of the installation began to turn unprofitable due to two mayor reasons: first, the progressive decrease in the CHP bonus (as part of remuneration after the CHP Act) led to a zero CHP bonus already in 2007. The second reason is the inappropriate system design as the huge thermal power installed faces a relatively small heating demand, especially in summer. Therefore, alternative electricity marketing options other than remuneration after CHP Act are assessed and presented in the following.

A first option is a fuel substitution from natural gas towards upgraded biogas. The German Renewable Energy Act (EEG) amendment from 2009 allows remuneration after EEG for both local combustion of biogas and combustion of upgraded biogas fed into the natural gas grid and combusted at a site other than the biogas plant. This aims at a more demand oriented renewable energy generation as biogas plants generally can be found in rural areas, far from bigger (constant) heat consumers. Heat generated in combination with electricity cannot be totally consumed at the local biogas plant, but upgraded biogas can be transported via the gas grid infrastructure to the consumers. Remuneration of electricity from smaller biogas fuelled CHP plants consists of the following components:

Remuneration components	**Remuneration [€ct/kWh]**
Basic remuneration	11.67
bonus for renewable raw material	7.0
technology bonus (for biogas upgrading)	2.0
CHP bonus	3.0
Sum	23.67
Fuel costs	
Natural gas	4.7
Upgraded biogas	8.5

Table 2: Remuneration of smaller biogas CHP plants after EEG, fuel costs

The numbers show that significant economic improvement can be expected from a fuel switch towards upgraded biogas.

A second option is a combined selling of the electricity generated directly into the spot market, without remuneration after CHP Act, and offering tertiary control (furthermore Minutenreserve) at the power reserve market. The “fair price” as part of the CHP Act is the quarterly average EEX (European Electricity Exchange) price for base load electricity. Trading into the spot market for selected hours that lie over the average base load price may lead to economic improvements, and combined offering of Minutenreserve makes further improvements to the plant’s economics. Minutenreserve can be both offered in positive (increase of electricity generation) and negative (decrease of electricity generation) direction. It is important to mention that at the power reserve market a bidding process is carried out where bids are sorted according to a merit order and accepted up to the total amount of Minutenreserve tendered. This implies the risk of acceptance or rejection, depending on the number of bidding parties. Data concerning the German power reserve market can be retrieved from www.regelleistung.net. Offering of Minutenreserve availability must be distinguished from Minutenreserve activation. Mere availability of Minutenreserve (per kW) is paid in any case, but the activation price (per kWh) is only paid in case of physical delivery/demand of electricity. Until now, the activation of Minutenreserve makes comparably small contributions to the balancing mechanism in Germany (see Table 3). Therefore activation of Minutenreserve is not included in the energyPRO calculations.

	Tender [MW]	**Activation [GWh]**
Secondary control, positive	3350	3027
Secondary control, negative	2470	4739
Minutenreserve, positive	3420	126
Minutenreserve, negative	2250	235

Table 3: Tender and activation of Secondary control and Minutenreserve, year 2007 [BNetzA, 2008, pp.47-55]

Table 3 shows that activation of negative control dominates. In Denmark, where direct electricity trading for smaller CHP plants started in 2005, the share of Minutenreserve activated is of about the same volume as secondary control activated. Further research in cost comparison between Danish and German imbalance settlement mechanism could provide information about their cost efficiency.

OPTIMISATION

In order to realise simulations for optimised operation schedules the “Friesenheim” installation has been modelled in energyPRO, a modelling software package developed for combined techno-economic analysis and optimisation of cogeneration. The software has the advantage to input a wide range of data, e.g. different energy plant types, degree day data, demands and profiles, plant operating strategies, tariff structures, spot prices, Minutenreserve availability costs, and revenues and operating costs, within the same calculation. The software provides reports with technical and economical results of the optimisation, and graphical visualisation of schedules and state of operation for the installation’s components. Calculations can be done either on a short term monthly base or on annual base. In the following, the different operation strategies are presented for September, 2008, and further on for July, 2008, and December, 2007, in order to show dependence on seasonal changes, too. Measure for economical efficiency is the net heat production costs (NHPC) that need to be minimised.

First, the heat driven reference case is presented shortly, where remuneration depends on the CHP Act. Due to high natural gas prices and comparably low feed-in tariff, the CHP plant operation in September 2008 leads to NHPC of 28,259 €. With a 242 MWh of heat generated the specific NHPC amount 117 €/MWh. In fact, heat production merely from the peak load boilers would be cheaper, representing 26,144 € and 108 €/MWh respectively. Simulating heat demand driven operation for July, 2008, NHPC turn even more inefficient with an amount of 17,862 € for generating 74.5 MWh of heat, a specific NHPC of 240 €/MWh. This is due to fix costs like operation and maintenance costs that are not covered by small revenues from reduced heat delivery. NHPC for December, 2007, is 65,748 € for generating 597 MWh heat, which costs 110 €/MWh heat. This high NHPC result from lower electricity remuneration (EEX baseload price for the 3rd quarter of 2007 amounted 31 €/MWh electricity). Besides, increased heat supply is not able to cover the fix costs. Summarising, NHPC are still enormous compared to representative decentralised NHPC of about 80 €/MWh [3N, 2009].

Second, direct electricity trading into the spot market is presented as an alternative marketing option. Electricity prices are taken from historical data sets provided by the EEX. In this case, total NHPC for September, 2008, are reduced to 19,495 €, representing 81 €/MWh heat. In July, 2008, NHPC rise to 15,031 € and 202 €/MWh, representatively, due to decreased heat demand. In December, 2007 where spot market prices were relatively low energyPRO simulation calculated NHPC of 40,645 € and specific NHPC of 68 €/MWh. The Simulation results show that through direct electricity trading into the spot market NHPC are improved by 15 % (summer) to 40 % (winter), depending on the season.

Third, combined trading into the spot market and offering positive and negative Minutenreserve was simulated. For this purpose, average bidding prices for accepted offers of both positive and negative Minutenreserve have been built and included into the optimisation. Simulation results show that especially offering positive Minutenreserve decreases NHPC substantially. The impact of offering negative Minutenreserve is comparably low because bidding prices are only high in the night time, and optimised CHP operation is during the day with higher electricity spot prices and positive Minutenreserve bidding prices. In September, 2008, total NHPC decrease to 9,309 € for generating 242 MWh of heat, and 38 €/MWh, respectively. For both July, 2008, and December, 2007, NHPC turn negative (-282 €/MWh in July, and -74 €/MWh in December). This is mainly due to high gains for offering Minutenreserve. In July decreased heat demand enables offering of higher shares of positive Minutenreserve, and in December offering Minutenreserve is prioritised due to comparable low electricity spot prices and very high Minutenreserve prices. Consequently, the peak load boilers are in increased operation.

Finally, results of the optimisation cases are summarised and compared to the heat driven reference case in the following figure.

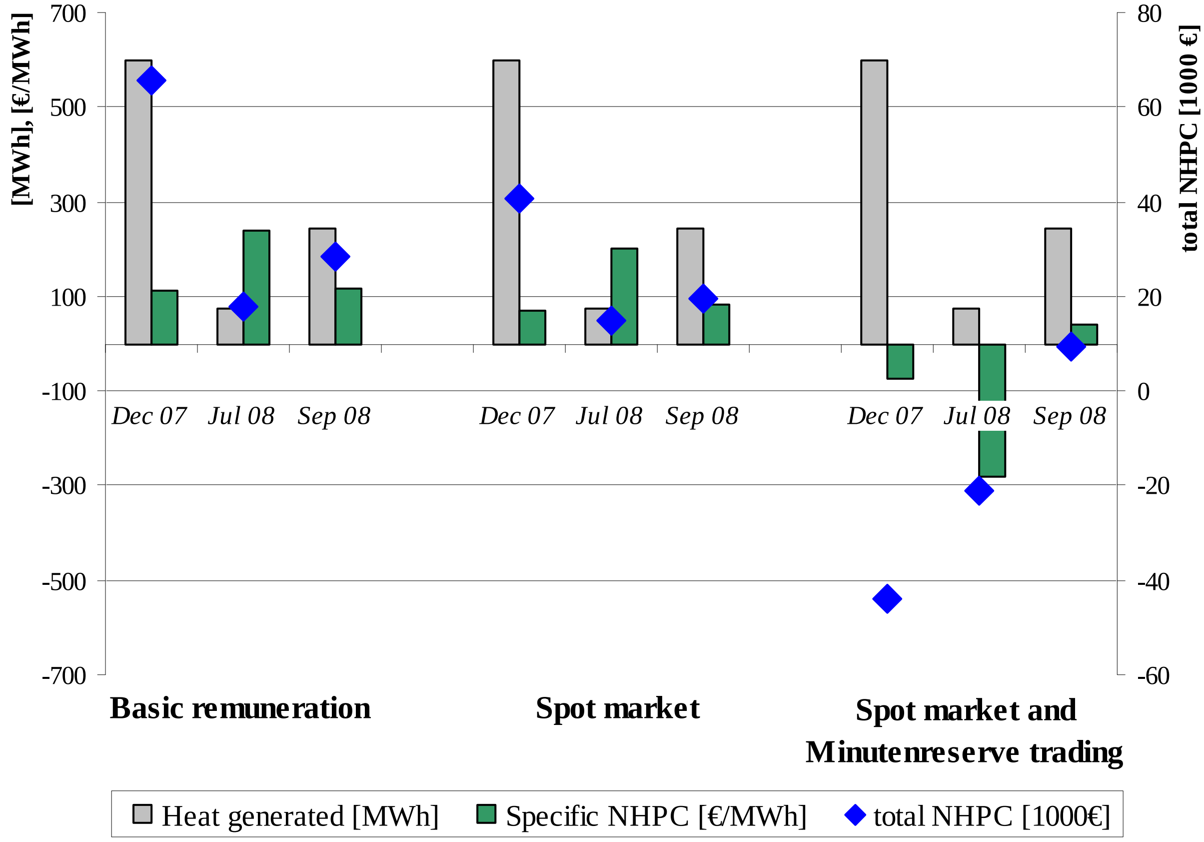

Figure 1: Electricity driven energyPRO optimisation results and heat driven reference case

The small difference between “Basic remuneration” case and “Spot market” case is remarkable, compared to NHPC behaviour in the “Spot market and Minutenreserve” case.

SENSITIVITY ANALYSIS

This analysis is done to determine how sensitive the optimisation results are. Parameters on which sensitivity is analysed are the EEX electricity spot prices, the primary energy price (natural gas), and the size of the thermal storage. Sensitivity is analysed for the “Spot market” case and September, 2008. Values for the parameters have been increased and decreased by 10, 20 and 30%. The results showed that sensitivity to natural gas price changes is highest, followed by sensitivity to EEX electricity spot prices. Varying the size of the thermal storage has no significant impact on the specific NHPC. The results are shown in the following figure.

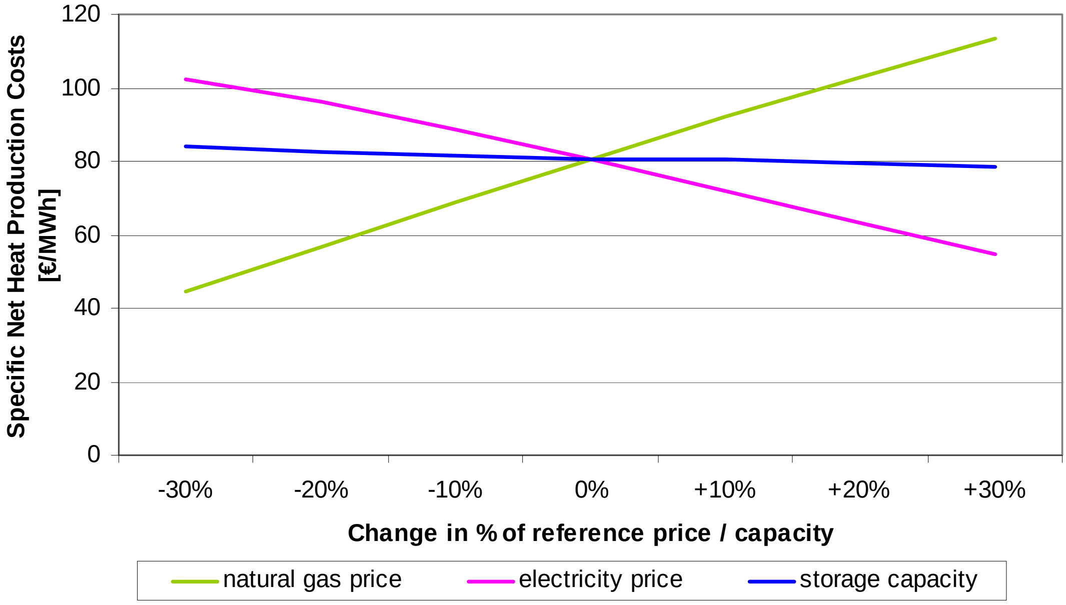

Figure 2: Sensitivity analysis for the "Spot market" case, September 2008

EEX electricity spot prices are often influenced by natural gas price changes. Therefore, if these prices change into the same direction, influences on the NHPC are minimised. But nevertheless, an increase in these prices increases NHPC, too, and vice versa, as sensitivity to the natural gas price is higher.

Conclusion and Discussion

The assessment of different electricity marketing options for the "Friesenheim" CHP installation showed that economics can be improved substantially by establishing electricity driven operation strategies. Combined trading into the electricity spot market and the power reserve market is the most promising option identified, turning formerly high net heat production costs into negative costs, meaning that heat could be offered for free and feasibility of the installation is still assured. Nevertheless, a full economics calculation, including investment costs, has not been done in this paper.

As good negative Minutenreserve availability prices only occur during the night time the installation of an additional electric boiler could be useful for offering negative Minutenreserve. Nevertheless, as long as Minutenreserve activation stays at the current low level in Germany, the options for improving economics of "Friesenheim" are reduced to offering Minutenreserve availability only.

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